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ABSTRACT

Among the factors least likely to be given due consideration, especially in computer assisted instruction, are student variables. Some reasons which might have hindered research activities involving student, and possibly teacher, cognitive mapping behaviors, learning styles, and media preferences as variables in experimentation are summarized: a public distaste for appraisal of individual intelligence and aptitude factors in students; aversion to the dehumanizing aspects of computerized instructional systems; suspicion of television, educational or other, engendered by the mass media; ignorance of the nature and potential educational significance of learning styles, cognitive mapping behaviors, and media preferences; and a history of difficulty in dealing with these concepts. The three areas of empirical investigation recommended for testing include those which concern the differential effects on student learning of taking into account facets of individual differences compared with not taking them into account; the differential effects on attitudes towards particular types of learning; and the differential effects on learning and attitudes towards learning of various kinds, when students are additionally provided with controls over particular aspects of the instruction/learning process. (VT)

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"COGNITIVE MAPPING", "LEARNING STYLES", AND "SENSORY MODALITY PREFERENCES" AS FACTORS IN INDIVIDUALIZED INSTRUCTION: A POSITION PAPER ON THE AS YET LARGELY UNTAPPED RESEARCH POTENTIAL OF INTEGRATED INFORMATION SYSTEMS WHEN COMBINED WITH EDUCATIONAL TECHNOLOGY

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Ideally, fully "custom-tailored" instruction should, in the provision of learning services, take into account all of the facets of individual differences which might "make a difference" in instruction/learning. Currently, among the factors least likely to be given due consideration, especially in computer assisted instruction (CAI), are the "learning styles", "cognitive maps", and "sensory modality" or "media preferences" of students. In particular, their propensity or otherwise, to make use of the newer integrated information systems and instructional media, especially the electronic media, is almost universally ignored and/or taken for granted. Instead, it is the instructor's propensities, if any, in combination with the characteristics of the information system at his/her disposal, which are likely to be taken into account.

Before launching into a summary of a few of the principal reasons for the previous, and to a large extent still current lack of empirical educational research involving the foregoing student variables, it would probably be well to provide some tentative definitions of a few of the key terms used in this new, technology-based research area, where the terminology still tends to be overlapping, fuzzy, and ill-defined.

First, the term "interactive, integrated, multi-media, information/communication, instruction/learning system" is intended to convey the notion of an interdependent system which has most, if not all of the following attributes:

1. It permits man-machine communication and interaction, as well as interaction/communication between the hardware and software of its sub-systems. It may also permit man-man interaction/communication.
2. It permits the recording of the foregoing transactions.

3. It permits, if desired by its users and/or if required by the system, the transactions to occur "on-line" and "in real time".

4. It permits, to its users, immediate or almost immediate, random or almost random, remote as well as local access to duly authorized portions of the foregoing recorded transactions.

5. It permits the dissemination and display of both recorded and live "on-line" transactions in a variety of media formats, including monophonic and stereophonic sound, and monochromatic or polychromatic, graphic, static and/or dynamic, visual, multi-dimensional transmissions and presentations.

6. It permits the generation, production, organization, recording, storage, and retrieval of libraries and/or data banks of multi-media information, with the retrieval and display of that information being available to users on the same bases as the recorded transactions noted in points #4 and #5 above.

7. It permits the interaction of its users with the foregoing transactions, libraries, and/or data banks in terms of text editing/composing capabilities, print-out capabilities, etc.

8. It permits the collection, recording, arranging, and retrieval/display of statistical information related to the transactions/interactions of users with each other, with parts of the system, and/or with the information recorded/stored in the system itself, as well as information related to the transactions/interactions of parts of the system with each other.

9. It permits the sytem and/or its users to manipulate or "massage" the foregoing statistical information, and, through the application of various "built-in" statistical techniques, to undertake analyses (including those required by full-scale, multi-factorial experimental designs and/or those involving multi-dimensional matrices) and interpretations thereof, possibly in order to facilitate modifications by the users and/or the system of the subsequent transactions between the users and the system, and/or between the users themselves.

10. It permits the system, when fully developed, to comprise a self-modifying, learning, "holistic" macro-system, capable of simultaneously engaging in interactive instruction/learning and/or simulation/gaming processes in conjunction with its users, and also of engaging in assisting its users in research endeavours related to its foregoing capabilities.

"Cognitive mapping or structuring" or "information mapping or structuring" is the more or less systematic mental procedure in which one engages for the formatting/organizing of verbal/print-alpha/numeric and/or pictorial information, such as concepts, meta concepts, and the relations between them, etc., into theoretical and/or practical knowledge.

"Cognitive (style) maps" or "mental structures" may be deemed to consist of three separate sub-components:

1. The types of symbols the individual uses most aptly or capably.
2. The cultural factors which influence his/her interpretation(s) of those symbols.
3. His/her methods of decision-making, based upon the symbols and their

interpretation(s).

"Learning styles", on the other hand, may be "cognitive" or "affective", or a combination of both. Cognitive learning styles, depending on the extant learning circumstances, comprise one's preferred ways of collecting and organizing information into theoretical and/or practical knowledge. They are also closely associated with one's interests, abilities/aptitudes, and self-concept. In contrast, affective learning styles, again depending on the given learning circumstances, comprise one's preferred overall temperamental and attitudinal stance with reference to the collection and organization of information, etc., and/or with reference to learning in general. They, too, are closely associated th one's interests, abilities, self-concept, and the like.

Some of the reasons which might be adduced for the existing state of affairs, which have hindered research activities involving student, and possibly teacher cognitive mapping behaviours, learning styles, and media preferences as variables in experimentation, would include:

1. The current state of disfavor, both among the members of the public and among educators, which has befallen all manner of educational tests which seek to appraise the intellectual abilities and/or backgrounds of students and, in turn, to relate the results of such tests to achievement in, and/or mastery of, new subject matter.

2. The widespread suspicion with which information systems of all types are regarded, rightly or wrongly, even by educators/researchers, as a result of the potential of such systems to foster invasions of privacy and "big brother" controls on freedom, etc.

3. The suspicion with which much of the content purveyed by the mass media, particularly the current forms of television - educational and other - is viewed, with respect to its assumed potential for engendering violence, disrespect for the law, unbridled freedom, irresponsibility, etc.

4. The low level, among persons engaged in learning research activities, of knowledge about, and appreciation of, the nature and the potential educational significance of learning styles, cognitive mapping behaviours, and media preferences.

5. The lengthy history of extreme difficulty encumbering previous attempts to define, to determine the precise nature of, and to effectively prescribe appropriate individualized learning environments and engagements, based on the consideration of the above-referred-to individual student variables of learning styles, cognitive mapping propensities, and media preferences.

Moreover, previous types of computerized experimentation, particularly those involving CAI, have tended to be limited both by cost factors and by the state of the art of man-machine communications. We have been inclined, for example, to concentrate on the use of terminals whose inputs and outputs required their users to have reading and typewriting skills, Skills involving pictorial discriminations have seldom been investigated. Facial expressions, gestures, and the like, were, and still are seldom used as experimental variables, not only because these phenomena are still beyond our ability to encode readily in a manner suitable for hypothesis testing and generalization, but also because of the still relatively high additional costs which would be

incurred in such research. Because we wanted to be able to fully and easily record, tabulate, and analyze the symbolic content of information exchanges, we have tended to separate the relevant human participants and to use the most common man-machine recorded medium - the teletypewriter - even though we had the capability to connect said participants by means of such media as telephones, linked typewriters, computer mediated exchanges (as in computer conferencing), etc.

Hence, numerous technological impedimenta, as well as attitudinal and cost considerations, have contributed to the past sparcity of experimentation concerning the three factors emphasized in this paper. Nevertheless, concurrently present, along with the foregoing phenomena and trends, there is apparent an increasing familiarity, among many segments of the population, with numerous computerized services, with automated information systems, and with the various media of communication, especially the electronic media.

Moreover, despite the prevailing attitudes of suspicion and hostility on the part of large segments of the population toward the "computerization" of society, there appears to be a considerable consensus everywhere that Western societies are beyond the point of no return with regard to the matter of computerization and the continuous development of even more complex and sophisticated information systems and networks. Hence educators and educational institutions are, perforce, feeling themselves in an "if we can't beat them, let's join them" situation.

The increasing acceptance and utility of computers as part of our way of life have now doubtless modified some attitudes to experimentation involving the application of computers in education. These changes, together with the

acceptance of other recent technological developments, have now rendered possible some educational research endeavours previously feared, eschewed, deemed unfeasible, or too costly. At least in the view of a small but growing number of researchers, the vastly increased accessibility of a variety of types of computer terminals, including several "intelligent" teletypewriter and cathode ray tube species; the rising availability and use of time-shared "on-line" computer applications; the rapid upsurge in the uses of advanced micrographic or reprographic systems; the numerous experimental and practical applications of telephone, television, and computer conferencing techniques; and the successful operation of student-directed computer assisted learning systems and/or information retrieval systems - all have now conspired to draw the would-be and well-endowed researcher into activity in this newly amalgamated and integrated high technology area of research concern, including investigation of the possibly powerful roles of the three facets of individual learning characteristics stipulated above.

There appear to be several major classes of learning activities or processes in which cognitive mapping behaviours, learning styles, and media preferences may more readily than otherwise be researched, approached, and possibly taken into account via integrated multi-media information/learning systems. In learning situations involving information searching, problem-solving, and decision-making, the learner's attention and motivation is likely to be focused upon information which he/she deems relevant to the formulation of possible and appropriate purposive, orderly, and definite acts or behaviours. This phenomenon may be viewed as a process by which possibly isolated elements, such as facts or concepts, classes, sentences, and other combinations, form patterns or cognitive maps, and are then built into the structure and the

dynamics of the man-information system and/or the man-self dialogue. In such instances, the resultant cognitive conceptual semantic maps or structures may be said to be based, at least in part, on the goal-directed purpose for which the new information was sought and mentally processed.

These procedures have implications for the formalization of multi-dimensional cognitive maps and conceptual switching mechanisms and schemata. In connection with problem-solving studies, for example, the researcher could advantageously make use of computer and media technologies in examining student information searching activities, such as the use of "on-line" citation indexes and/or full-text data bases in following particular semantic road maps and association patterns, in heuristic searching within pragmatic settings embracing particular portions of the universe of knowledge. And again in the case of the researcher, his work could involve the deployment of the system's monitoring capabilities and computerized statistical procedures, in order to observe, to analyze, and possibly to manipulate the on-going learning process. Presumably integrated technologies could thus permit the researcher, and the student as well, at least in a few specific areas of learning activity, such as the aforementioned heuristic type of information searching (including the pre-sorting behaviours, the anticipatory organization/structuring, and the logistics of the mental handling of information or its surrogates), to attempt to perceive and trace the individual semantic/cognitive road maps and the associative conceptual patterns and linkages constructed by the student.

According to Norman and Rumelhart (1975); Greeno (1976); and Norman, Gentner, and Stevens (1976), computer generated cognitive maps can now be constructed and used to describe, spatially, the manner in which concepts may

be "organized" in memory. And such maps, as Preece (1976) and Shavelson (1972, 1974) have shown, may be used in a variety of ways in connection with experiments on learning. Moreover, these maps may themselves be used as integral parts - often in the form of block diagrams - of instructional materials (Spangenberg, 1971).

The new integrated multi-media information/learning systems could presumably permit the researcher to study student information-searchers/problem-solvers and/or decision-makers who seek to simulate and to enact such scenarios as: if these are the prevailing conditions and this is my present state of affairs, and if I make this or that move or action, then the following will be the results, and my next situation will be thus and so. These conditions, states and events could form suites, the alternative paths and hypotheses of which could be modelled or simulated, and hence explored and tested.

In learning situations involving knowledge transmission/transfer, it could be claimed that the process comprises an interaction, an information exchange dialogue, between a sender and a receiver in which each has his/her own set(s) of goals, motivations, resistances, values, and understandings. For both, the challenge entailed is the discovery and provision, through feedback, of the appropriate facilities - mechanisms, media, and strategies - of sending and receiving, which each not only is aware of, but also accepts, has access to, and feels competent and comfortable to handle.

The evidence that verbal/printed information is likely to be processed differently from pictorial information, and that combined pictorial and verbal information is likely to be processed still differently, is indicative of the ways in which differing media may affect the content and the structuring of

concepts in human memory and cognition. Moreover, the characteristics of particular media can virtually dictate the kinds of messages which may be transmitted by the media in question. Hence the students' or their teachers' media preferences may be counterproductive when implemented in particular types of learning situations. Moreover, such preferences would inevitably interact with and affect the meaning and the cognitive maps of the learners, and vice versa.

In the teacher's selection of the appropriate media to be used among the possibly many available in a particular integrated information system - in many ways a sorting and classification task - and in the actual selection of, say, a particular film from among several available and relevant to the teaching of a particular concept and/or construct, the teacher whose "style" is of a particular type (à la Royce, 1977) might give more weight, say, to the particular characteristics of the media from among which a choice is to be made, than would another instructor with a different style. The former might, for example, prefer, for teaching/learning purposes, for his/her students, media items invoking perceptual and inductive reasoning functions, rather than those involving conceptual and deductive reasoning characteristics. Similarly, a teacher in whom an affective style predominates would intuitively tend to have that affective style moderate, and hence perhaps determine, by the implicit or explicit expression of, say, feelings of anxiety or impulsivity, the decision in the aforementioned selection/sorting classification tasks. All of this information processing activity within the mind of the teacher could, of course, in theory, occur in partial or total disregard of the respective cognitive and affective styles of each of the students in the group. Or alternatively, insofar as he/she was aware of them, the teacher might attempt to disregard

his/her own inclinations, and endeavour, instead, to accommodate his/her teaching style and the learning resources available to the respective styles of the students, again, insofar as he/she was aware of them. Given such insights, he/she would probably, however, attempt to effect a compromise between his/her own style and those of the students.

Similarly, the learning style of the student and the type of learning called for (e.g., inductive or deductive) may either inhibit or facilitate the learning process. Hence, cognitive mapping predilections, learning styles and media preferences may interact not only with each other but also with the content and the types of learning task(s) at hand. Hence, too, the maximizing of learning with the optimization of continued interest on the part of the student is the name of the game which instructors and the integrated and computerized systems must play.

These many possibilities and their respective concommitants, as well as their effects on the subsequent nature of the learning processes in question, could all be monitored and hence better-fathomed by educators, through the deployment of an appropriate integrated information system.

Then too, as a result of recent advances in statistical methods for frequency and enumeration data analyses, such as the use of log-linear models for occurence probabilities in complex cross-classifications of qualitative events, it is currently possible to perform multivariate analyses on qualitative data in much the same manner as the comprehensive and detailed analyses on quantitative data have long been performed via analysis of variance, etc., on measurement data. At the University of Chicago, for example, Bock, Woods, and Yates (in preparation, 1978) have apparently developed a powerful, user-oriented, computer program for log-linear analyses of nominal or ordinal

qualitative data, by the method of maximum likelihood.

Hence, just as preferences for reading material in children's texbooks can be related to average word frequency and average sentence length, in order to find optimal levels of difficulty for given learner groups, so, too, can learner preferences for particular media formats, such as television pictures versus printed texts, now be related to other variables. Such variables might include, for example, aptitudes with regard to particular types of learning materials and learning styles, used to ascertain and to prescribe optimal levels of particular types of learning content for given individuals or groups.

Moreover, log-linear analyses presumably now permit the investigation and comparison of trends in Piagetian or other cognitive mapping and learning style attainments as a function of maturation in relation to various other background characteristics, even while the students being studied are engaged in their learning activities and processes. Additionally, through longitudinal case studies, in which the integrated information/learning system "models" students over the course of time, the system could presumably build up a multidimensional cognitive, stylistic, and media-preference "profile" of each student, an updateable profile which could, in turn, be used for the individualized instruction of that student.

At least in theory, then, the use of these new combined technolgies render possible the provision, in various subject matter fields, of automated instructional assistants which hopefully could continue to engage students in appropriately challenging and personally intriguing printed and/or, if need be, mediated demonstrations, via the use of such techniques as computerized instructional simulation and graphic metaphors (e.g., diagrams).

In virtually all of the foregoing situations, the instruction and learning in question could be conceived of as a process wherein the participants (teachers and learners) attempt to create and transmit messages to each other within the system, such that all of the right information, and only the right information, is transmitted to all of the right persons, and only the right persons, at the right time and place, in the right format, and at a cost affordable to all concerned. The capabilities of the information system to monitor the interchanges, to make the participants aware of their own and the other participants' maps, styles, and media preferences, could presumably assist in the maximization of the effectiveness of such endeavours. And the capability of the researcher to monitor and study the entire process could also presumably lead to the perfection of the information/learning system, and hence, to the further improvement of the learning activity.

Then too, integrated information/instructional/learning systems could be used in "product testing" research designed to assist in mapping out sets of procedures for the designers of such sophisticated information systems, whereby the new knowledge of learners and, in turn, the learning gained through the operation of such systems, could subsequently be used to develop even more effective instructional/learning systems, ones which could cater not only to the needs of groups of students in institutional settings but also to the needs of individuals in all manner of learning environments.

In the view of the present author, the foregoing exemplars of current and possible research endeavours provide a basis for a generalized summary of what may be regarded as three potentially fruitful general areas of empirical investigation, in which the sophisticated type of information/learning systems referred to herein might usefully be employed in relation to the three student

and teacher variables here under consideration. The summary consists of a series of types of hypotheses recommended for testing. In the case of each type of hypothesis, numerous factors are indicated as potentially involved independent or dependent variables. It is not intended, however, that all of the noted variables would, in fact, be investigated in any one experimental endeavour. Rather, it is the range of experimental possibilities which is being suggested.

The three areas of empirical investigation recommended for testing include those which concern:

1. The differential effects, if any, on the quality and/or quantity of the learning which occurs on the part of various student population groups (such as those based on age, sex, physical handicaps, etc.) when they are provided with learning facilities (i.e., hardware, software, and an appropriate learning environment) capable of taking into account the individual's and the group's aptitudes in the learning of various types of subject-matter content and in the attainment of various levels and types of learning objectives (e.g., cognitive, psychomotor, and affective), as well as one or more other facets of individual differences such as their respective cognitive mapping behaviours, learning styles, and their media preferences, as compared with situations wherein no special account is taken by the information/learning system of the students' respective mapping, stylistic, and media preferences.

2. The differential effects, if any, on <u>attitudes towards particular types of learning</u> on the part of the foregoing student populations when

their aforementioned mapping habits and media preferences are either taken into account or not taken into account by the instructional/learning system.

3. The differential effects, if any, on learning, and attitudes towards learning of various kinds, on the part of the foregoing student population, when not only certain of the foregoing variables are experimentally manipulated but also when the students are additionally provided with various levels and degrees of optional control over particular aspects of the instruction/learning process, such as the content to be studied, the objectives to be attained, etc.

It should perhaps be noted in passing that not only educational researchers are being constrained to delve into research tasks similar to those under discussion. Information scientists at the School of Information Studies, Syracuse University, for example, have researched or are researching such varied topics as: "The Effect of Individual Cognitive Styles on the Judgement of Document Relevance in Information Retrieval Systems"; "The Effects of Cognitive Style and Information Load on Process in a Decision-Making Task"; "Cognitive Similarity, Communication Similarity, and Communication Effectiveness"; and "The Effect of Cognitive Social Learning Within Intrapersonal Dyadic Communication on Problem Solving in an Information Seeking Situation".

The relatively newly available possibilities for the detection, the tracing, and the taking into account, in instruction/learning processes of multidimensional, conceptual/cognitive/semantic "mapping schema" and behaviours, and conceptual switching systems, learning styles, and media preferences of students, via integrated multi-media information/learning systems, could probably bear important implications with respect to the future provision of individualized

learning activities. Even though human instructors will remain as the principal faciltators of learning, the availability of such facilities would presumably be enormously helpful in rendering possible the eventual automation of the simultaneous provision, to large numbers of students, of truly "custom-tailored" instruction/learning materials, based on the students' respective individual needs and interests and presented in the most appropriate formats.

Although a small but increasing number of researchers have used instructional materials and systems of varying sophistication for the study of cognitive mapping processes, learning styles, conceptual switching systems, and/or media preferences, and although other or the identical researchers have increasingly used sophisticated computerized statistical techniques for the recording, the analysis, and even the interpretation of their data, very few have, as yet, utilized "on-line" interactive multi-media information/instruction/learning systems wherein the systems themselves comprise on-going learning entities, entities which can, in "real time", improve their performance based upon their on-going experience in interacting with "on-line" live human learners. When such systems eventually are able to incorporate the most advanced statistical techniques for dealing with either qualitative or quantitative data or both, when they are able to incorporate the full measure of available and appropriate procedures for dealing with the implied or explicit structures of various types of knowledge, as well as with the multifarious ways in which learners' process information and cognitively structure or map knowledge - many of which are described in Winn (1978); and when they additionally are able to jointly take into consideration not only the ways in which learners' cognitive structures are formed and changed but also the ways in which student learning styles, aptitudes, and media preferences differ and affect learning, then a new

dimension, a "quantum leap" in instruction may well have been achieved. It is the arduous research task of the gradual building of such super systems that is herein recommended to the audience of this paper.

An example of a step toward the building of such an integrated multi-media information/instruction/learning system may be seen in the development, as reported in Goodman and Winn (1977), at the Learning Technology Unit of the University of Calgary, of a computerized video cassette instructional simulation system. The system currently has the capability of rapid, remote, and almost random access to stored, synchronized, monophonic and/or stereophonic sound, and to colored and/or black and white visual information, as well as access to "live" radio and television programs. It also has the capability of being coupled to technologically advanced microform systems, such as random access synchronized audio cassette-full color microfiche or microcard mechanisms. It can also be coupled to an existing multi-media multiple student response system (Edex). It may additionally be, but currently is not as yet coupled to other available computers and/or CAI systems capable of storing student responses to instructional materials, and/or capable of engaging in statistical analyses of these responses and of modifying the instructional materials accordingly. The system was accordingly designed and programmed to function in an interactive "on-line" mode, and, insofar as possible, in "real time".

This already-consumated marraige of several advanced technologies has the potential of lending itself to the use of a wide variety of information gathering, storage and retrieval techniques, instruction/learning experimentation, and instructional simulation, as well as to practical training activities, such as teacher education. As such, it is currently capable of providing individuals

or groups with a particular genre of learning experiences and materials and with a particular type of selective information display and dissemination service. The system, in a sense, thus entails actual or potential capabilities which embrace almost every aspect of the whole information-communication chain or process, from information production to information application or use.

It is accordingly suggested that advantage be taken of the power of this type of new information/communication technology, both to determine and to analyze the actual nature and role of the aforementioned learning variables, in order, in turn, to investigate the potentialities for their most effective educational deployment, and hence for the attainment of hopefully widespread eventual instructional improvements, at least in the technologically and educationally advanced nations.

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